International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2021; 9(1): 2653-2657

Received: 27-11-2020
Accepted: 30-12-2020

Tabbu Theba
Research Scholar, College of Food Processing Technology and Bio-Energy, Anand Agricultural University, Anand, Gujarat, India

Amee Ravani
Assistant Professor, College of Food Processing Technology and Bio-Energy, Anand Agricultural University, Anand, Gujarat, India

HG Bhatt
Associate Professor and Head, College of Food Processing Technology and Bio-Energy, Anand Agricultural University, Anand, Gujarat, India

Corresponding Author:
Amee Ravani
Assistant Professor, College of Food Processing Technology and Bio-Energy, Anand Agricultural University, Anand, Gujarat, India

Utilization of beetroot pomace for food fortification

Tabbu Theba, Amee Ravani and HG Bhatt

DOI: https://doi.org/10.22271/chemi.2021.v9.i1ak.11628

Abstract
Beetroot (*Beta vulgaris*) is a root vegetable also known as red beet, garden beet, table beet, or just beet. It is rich in indispensable nutrients as fibre, folate (vitamin B9), potassium, manganese, iron, and vitamin C. Beetroot pomace is waste from beetroot processing industry, it contains higher amount of betalains and phytochemicals which can be utilized in food applications. Large amount of pomace are cheap source of dietary fibre. Beetroot pomace contain various bioactive compounds and antioxidant activity. It is extensively used as additives in the food industry because of its natural and harmless pigments and colorant properties and absence of toxicity. Beetroot powder has many functional properties like water holding capacity, water retention capacity, swelling capacity and oil absorption capacity so it can be widely utilized in different food products like cookies, cake, snacks, candies, etc. Utilization of beetroot pomace is inexpensive and it can be used as effective functional ingredient.

Keywords: Beetroot pomace, bioactive compounds, dietary fiber, functional properties, value added products

1. Introduction

Nowadays, an environmental problem is a waste management on a daily basis. Wastes from processing of fruits and vegetables are increasingly used as a source of bioactive compounds such as polyphenols, carotenoids, tocopherols, and many others. These phytochemicals from waste materials may be used as functional food ingredients and as natural antioxidants to replace their synthetic equivalents that have experienced growing rejection (Vuli´c *et al*., 2012; Mena *et al*., 2014) [21, 11].

Natural pigments have important applications in the field of medicine, foods and cosmetic industries (Azeredo, 2009) [1]. Now a day, food and beverage industries are focusing largely towards the natural colours due to their high colouring properties and non-toxic effects (Kearsley & Katsaboxakis, 1980) [6]. Since, natural pigments are more health beneficial than synthetic colours and do not show any side effect on human body hence, the use of synthetic food colourants is restricted by legal regulations of both international and national authorities (Maran *et al*., 2015) [10]. However, natural colourants have many disadvantages including higher cost in-use and lower stability when compared to synthetic ones (Azeredo, 2009) [1]. The major source of betalains pigment is beetroot (*Beta vulgaris*) which is an alternative to synthetic colours. Beetroot is the 10th most powerful vegetable with antioxidant properties which contains phenolic compound, carotenoids, betalains, vitamins and minerals which are important biocompound and micronutrients (Vinson *et al*., 1998) [20].

Beetroot is ranked among the 10 most powerful vegetables with respect to antioxidant capacity ascribed to a total phenolic content of 50–60 lmol/g dry weight (Ka¨hko¨nen *et al*., 1999; Vinson *et al*., 1998) [5, 20]. It contains a significant amount of phenolic acids: ferulic, protocatechuic, vanillic, p-coumaric, p-hydroxybenzoic and syringic acids (Kujala *et al*., 2000) [7]. Plant phenolics have received more attention in recent years because they are free radical scavengers and prevent active oxygen-induced and free radical mediated oxidation of biological molecules (Pedren˜o & Escribano, 2000) [14]. In addition, beetroot is a potential source of valuable water-soluble nitrogenous pigments, called betalains, which are composed of two main groups, the red betacyanins and the yellow betaxanthins (Pavlov *et al*., 2002) [13].

Beetroot is a popular plant food with nutritional benefits. Beetroot stands out among minimally processed vegetables because of the demand for healthy foods and for its practicality. This vegetable has functional characteristics due to its significant fiber content, both soluble and insoluble, which can provide interesting technological properties for the food industry, such as enrichment of pasta, cakes, and cookies (Dalla Costa *et al.*, 2017) [3]. In the modern food industry, betalains have been extensively used. They are one of the most important natural colorants and are also one of the earliest natural colorants developed for the use in food systems (Azeredo, 2009) [1]. An investigation showed that total phenolics content decreases in the order peel (50%), crown (37%), and flesh (13%) (Kujala *et al.*, 2000) [7]. However, most of the secondary plant metabolites and dietary fiber compounds are not transferred into the liquid phase during the dejuicing process and remain in the pomace after pressing (Will, 2000) [25]. The beetroot pomace from the juice industry (15–30%) is disposed of as feed and manure, though still rich in betalains and phenols. These wastes are high-value products and their recovery may be economically attractive, so these wastes as by-products are gaining an increasing interest (Schieber, 2001) [17].

Beetroot are high in folic acid amounting to 15.8 mg/g dry matter (Wang & Goldman, 1997) [24]. Folic acid is one of 10 essential vitamins in human diet and its value has been recognized in recent years by an important increment in governmentally recommended allowances from 400 to 800 mg for pregnant women in the US (Wang & Goldman, 1996) [23]. The beet root pomace is a potential source of natural antioxidant compounds for use as dietary or food antioxidant. The coloured portion of the beetroot ranges from 0.4 to 2.0% of the dry matter, depending on intraspecific variability, edaphic factors and postharvest treatments (Schieber, 2001) [17].

2. Characterization of beetroot pomace and its products

The bioactive compounds present in beetroot pomace, beetroot pomace extract and beetroot pomace extract is depicted in Table 1 to 3. Beetroot is a rich source of phytochemical compounds that includes ascorbic acid, carotenoids, phenolic acids and flavonoids. Beetroot is also one of the few vegetables that contain a group of highly bioactive pigments known as betalains. Beetroot pomace and its products also possess antioxidant activities as shown in table.

2.1 Beetroot pomace

Table 1: The content of bioactive compounds and antioxidant activity of beetroot pomace

Bioactive Compounds	Content (per 100 g Pomace Dry Weight)
Polyphenols	89.06 ± 4.62
Flavonoids	4.74 ± 0.16
Betacyanins	79.22 ± 2.04
Betaxanthins	80.06 ± 2.06
Gallic acid	7.45 ± 0.24
Protocatechuic acid	11.53 ± 0.40
p-Hydroxybenzoic acid	0.78 ± 0.02
Catechin	53.42 ± 1.53
Epicatechin	2.09 ± 0.08
Chlorogenic acid	0.30 ± 0.01
Caffeic acid	0.18 ± 0.00
Ferulic acid	0.48 ± 0.02
Sinapic acid	0.52 ± 0.03
Coumaric acid	0.34 ± 0.01
Myricetin	3.52 ± 0.14
Luteolin	0.03 ± 0.00
Quercetin	0.22 ± 0.10
Apigenin	0.10 ± 0.00
Isorhamnetin	0.35 ± 0.01
Betanin	88.94 ± 3.57
Vulgaxanthin-I	71.08 ± 1.33
Scavenging activity on DPPH (SA)	59.75 ± 2.09
Reducing power (RP)	206.84 ± 9.81

(Tumbas Šaponjac *et al.*, 2016) [19].

2.2 Beetroot pomace extract

Table 2: Antioxidant compounds, phenolic compounds and betalain compounds in beet root pomace extract

Antioxidant compounds		mg/g
Total phenolic compounds		117,863
Total flavonoids		54.844
Total betalains	Betacyanins	14,129
	Vulgaxanthins	8.324
Phenolic compounds		**mg/100 g of dry weight of beetroot pomace**
Caffeic acid		7.11 ± 0.22
Vanillic acid		5.12 ± 0.22
p-Hydroxybenzoic acid		1.13 ± 0.11
Ferulic acid		132.52 ± 3.31
Protocatechuic acid		5.42 ± 2.13
Catechin		37.96 ± 1.75
Epicatechin		0.39 ± 0.02
Rutin		0.25 ± 0.01
Betalain compounds		**mg/100 g of dry weight of beetroot pomace**
	Betanin	37.22 ± 1.62
Betacyanins	Isobetanin	17.95 ± 0.71
Betaxanthins	Vulgaxanthin I	0.71 ± 0.12

(Vulic *et al.*, 2014) [22].

2.3 Beetroot pomace powder

Table 3: Physical properties, proximate composition and functional properties of beetroot pomace powder

Physical properties	
Particle size distribution (%)	
212 µm	30.40

180 µm	11.88
150 µm	10.96
< 150 µm	46.76
Bulk Density (g/cm3)	0.631 ± 0.005
Tap Density (g/cm3)	0.451± 0.002
Proximate composition	**Percent (%)**
Moisture	6.82 ± 0.03
Fat	1.44 ± 0.03
Crude Fibre	11.12 ± 0.12
Ash	9.86 ± 0.15
Protein	15.85 ± 0.03
Carbohydrates	54.91
Functional properties	
Water Holding Capacity (g/g)	5.040 ± 0.104
Water Retention Capacity (g/g)	4.338 ± 0.087
Swelling Capacity (ml/g)	7.8 ± 0.00
Oil Absorption Capacity (g/g)	2.206 ± 0.064

(Sahni & Shere, 2017) [16].

Beet root (*Beta vulgaris* L.) ranks among the 10 most powerful vegetables with respect to its antioxidant capacity ascribed to a total phenolic content of 50–60 µmol/g dry weight.

3. Utilization of Beetroot Pomace

Beetroot pomace powders can be used as cheap, non-caloric bulking agents in food for partial replacement of flour, fat or sugar, as they tend to improve the functionality of food by enhancement of water and oil retention and improved emulsion stability (Elleuch *et al*., 2011) [4]. Beetroot pomace based food products and their processing are explained in Table 4. Beetroot pomace can be excellent source of phytochemicals along with dietary fibre. However, beetroot pomace powder can be used only upto 10% level where it improved the acceptability of cookies due to better taste and flavour. The incorporation of beetroot pomace upto 5% resulted in higher spreading and higher than 5% resulted in poor spreading of cookies. The incorporation at high level adversely affected the colour and appearance, and texture of the cookies thus, reducing overall acceptability of the cookies. When the level of incorporation increase beyond 5%, hardness of the cookies increased. Incorporation of beetroot pomace powder resulted in increase in the fibre content of cookies. The moisture, crude fibre, protein and ash increased whereas carbohydrate content decreased with the increase in the level of incorporation (Sahni and Shere, 2016) [15].

Beetroot waste and wheat flour husk are rich source of fibre. The crude fibre in Beetroot waste powder and wheat flour husk were containing 62.75% and 51.77% respectively. Cookies were prepared from beetroot waste powder and wheat flour husk. This combination was acceptable on the basis of sensory evaluation and also on the basis of high crude fibre and mineral content (Chauhan & Rajput, 2018) [2]. Parveen *et al*. (2017) [12] reported that biscuits high in fiber content can be prepared by substituting whole wheat flour with the addition of carrot pomace powder as well as beetroot pomace powder. Substitution of whole wheat flour with different levels of Carrot and beetroot pomace powder decreased the spread ratio of biscuits, whereas the thickness and weight increased with increase in the level of pomace powder. The incorporation of Carrot and beetroot pomace powder in the respective formulations has no significant effect on the overall acceptability of biscuits. The product was found to be more acceptable in terms of physico-chemical and sensory characteristics after fortification of fiber. Nutritionally, the biscuits made from blends contained more amount of ash content, crude fiber and moisture content than control biscuits but lower amount of carbohydrate, protein, calorific value and pH.

Table 4: Beetroot pomace based food products and their processing

Food Products	Processing	Reference
Fibre Rich Cookies	Beetroot pomace dried at 50 °C in cabinet dryer for 6 hours and then pulverized. Blends of 5%, 10%, 15%, 20% and 25% were prepared by substitution of refined wheat flour with beetroot pomace powder. The ingredients used in preparation of cookies were flour blends, fat, sugar, baking powder, sodium bicarbonate, ammonium bicarbonate and water as per the requirement for making dough. Dough was rolled and cut into circular shape with dye.	Sahni & Shere, 2016 [15]
Antioxidant rich ginger candy	Beetroot pomace dried in tray drier at 55 °C and ground into powder followed by sieving. Pomace extraction was done under optimum process conditions i.e. by diluting the pomace with acidic water (pH 2.5) in 1:15 solid to liquid ratio, followed by moderate temperature treatment in water bath at 50 ± 1 °C for 10 min. Ginger slices were blanched in boiling water containing 2% citric acid for 5–15 min followed by steeping in 75°Brix sugar syrup containing different concentrations of beetroot pomace extract (0–12.7%) and 2% citric acid. The steeped mass was drained after 24 h and dried at 50 °C for 1 h, cooled and packed in laminated aluminium pouches.	Kumar *et al*., 2018 [8]
Biscuits Enriched With Fibre	Carrot and beetroot pomace was dried in an oven at 65 ± 5°C and was ground to a fine powder then sieved through 60 mm mesh sieve. In different proportions dried pomace of carrot and beetroot was added to whole wheat flour, shortening, ground sugar, baking powder, baking soda and potable water. The dough was rolled out in a 3 mm thin uniform layer and cut into desirable shapes and baked at 170°C for 20 min. Biscuits were cooled, packed in air-tight boxes and stored at room temperature.	Parveen *et al*., 2017 [12]
Cake	Beetroot pomace dried at 50 °C for 6 hours and pulverized. Wheat flour, beetroot pomace powder and baking powder were blend and sieved. Together mix the butter, sugar, salt in the grease form, then add the sieved flour to make a dough and add the milk. Dough was placed in a battered cake mould. Cake was baked at 375°C for 30 min.	Manopriya & Arivuchudar, 2019 [9]

Gluten free and high fibre cookies	Beetroot pomace dried in tray dryer at 40-45 °C for 7-8 h and was ground and passed through sieve. All ingredients (beetroot waste powder, wheat flour husk, sugar, shortening, milk, sodium chloride, baking powder) were mixed and dough was prepared. After shitting and cutting, baking was carried at 150–180 °C for 15 min. and then cooled to room temperature and packed.	Chauhan & Rajput, 2018 [2]
Extruded product with Rice Flour Incorporated With Beetroot Pomace and Pulse Powder	Beetroot pomace dried at 60°C and The material was ground to pass through the sieve of 2 mm size. Rice flour was replaced with beetroot pomace and pulse powder mixture at levels of 15, 20, 25 and 30%. The moisture was adjusted by sprinkling distilled water in dry ingredients. All the ingredients were weighed and then mixed. After mixing, samples were stored in LDPE bags at room temperature. Sample was passed in single- screw extruder and then kept in hot air oven at 60°C for 1-2 hr.	Sinha, 2014 [18]

Kumar *et al*. (2018) [8] developed antioxidant rich ginger candy using beetroot pomace extract. Blanching time and beetroot pomace extract concentration exerted a significant effect on the phytochemical properties of the ginger candy. An increase in total phenolics, antioxidant activity, betacyanin and betaxanthin content of antioxidant rich ginger candy was observed with increase in beetroot pomace extract concentration. The optimum process conditions for production of antioxidant rich ginger candy was found to be 7.81 min blanching time and 9.24% beetroot pomace extract concentration with 0.905 desirability. The optimized conditions will help in increasing the phytochemical potential of the ginger candy as well as demonstrate to be a cost effective way for utilization of beetroot pomace.

In recent times, due to increasing nutritional awareness cakes are categorised as junk foods providing empty calories. Therefore, it becomes imperative that such adored snack foods are enhanced nutritionally by value addition so that the cakes are enriched with fibre and essential micronutrients. Pomace powders contain adequate fibre and nutraceuticals such as polyphenols which are discarded. Moreover, most of the pomace powders also act as natural colorant, provide aroma and flavour without perplexing the physiognomies of the foodstuffs into which they are integrated. Value added cake developed by incorporating beetroot pomace powder to refined wheat flour in the proportion of 10, 15 and 20%. Cake with 20% of beetroot pomace powder was highly accepted. The nutritional value of 20% of beetroot pomace powder incorporated cake was highly commendable. Therefore, beetroot pomace powder incorporated cakes can be commercialised for their antioxidant and fibre rich properties (Manopriya & Arivuchudar, 2019) [9].

Sinha & Masih (2014) [18] Studied on incorporation of beetroot pomace powder and pulse powder in noodles. For the development of beetroot incorporated noodles different levels of rice flour, pulse powder and beetroot pomace powder were added in the ratio of 100:00:00, 85:7.5:7.5, 80:10:10, 75:12.5:12.5 and 70:15:15. For control and beetroot fortified noodles physiochemical analysis was carried out. Fibre content increased as quantity of beetroot pomace powder increased. Color became darken as the level of beetroot pomace increased. Protein content was increased with increase in content of pulse powder. With increased proportion of beetroot pomace powder phosphorus, Iron and fat contents were increased. Based on sensory evaluation, noodles with 75:12.5:12.5 were found more acceptable than other levels and were found optimum for incorporation rice flour noodles for development of beetroot incorporated noodles. It was packed in LDPE and stored at room temperature. The storage studies were conducted for 45 days. During storage protein, iron crude, fibre, fat, phosphorus percentage was decreased.

4. Conclusion

Beetroot pomace, waste material after juice processing contains bountiful of bioactive compounds including antioxidants that confer added health benefit. Beetroot pomace can be used as a good source of phytochemicals along with dietary fibre and as a natural additive or functional foods. The process to obtain beetroot pomace powder is simple and generates a product with high fibre content, both soluble and insoluble, and high oil and water holding capacities. Beetroot pomace powder improve the acceptability of food products due to better taste, color and flavour. Beetroot pomace is an abundant low-cost source that can provide natural ingredients with functional appeal.

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